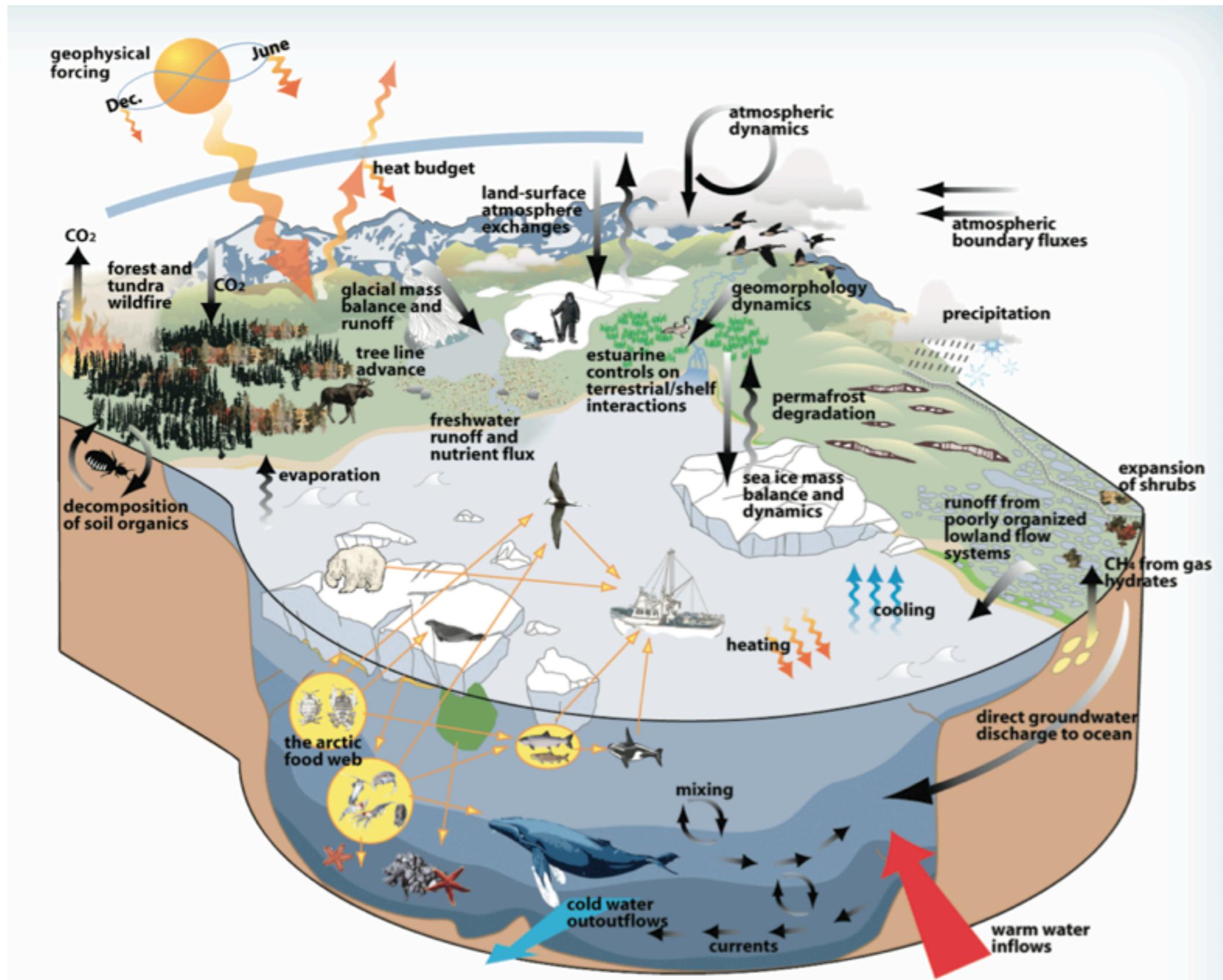


Present Day and 4xCO₂ simulations of the Arctic

**Melissa Burt
CMMAP Team Meeting
Coupled Models & Climate Change Breakout**

Arctic Climate System

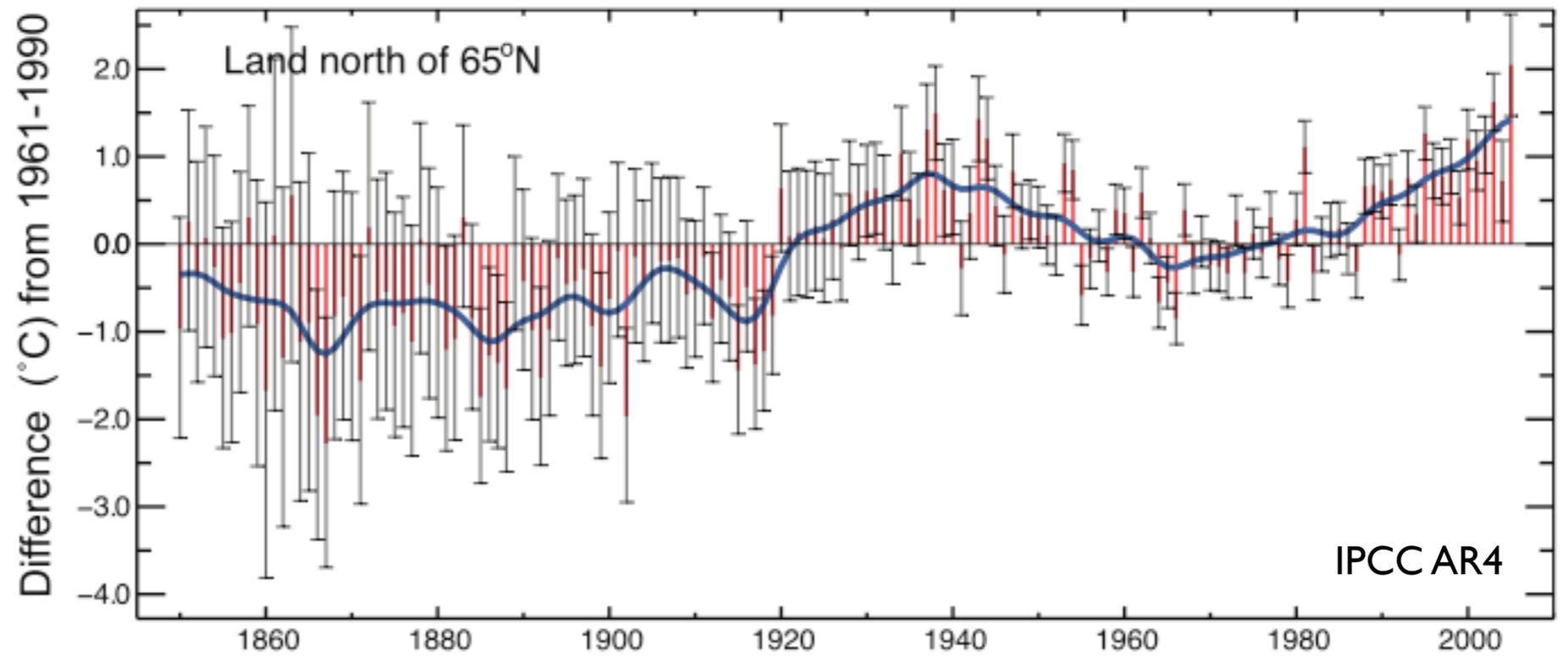
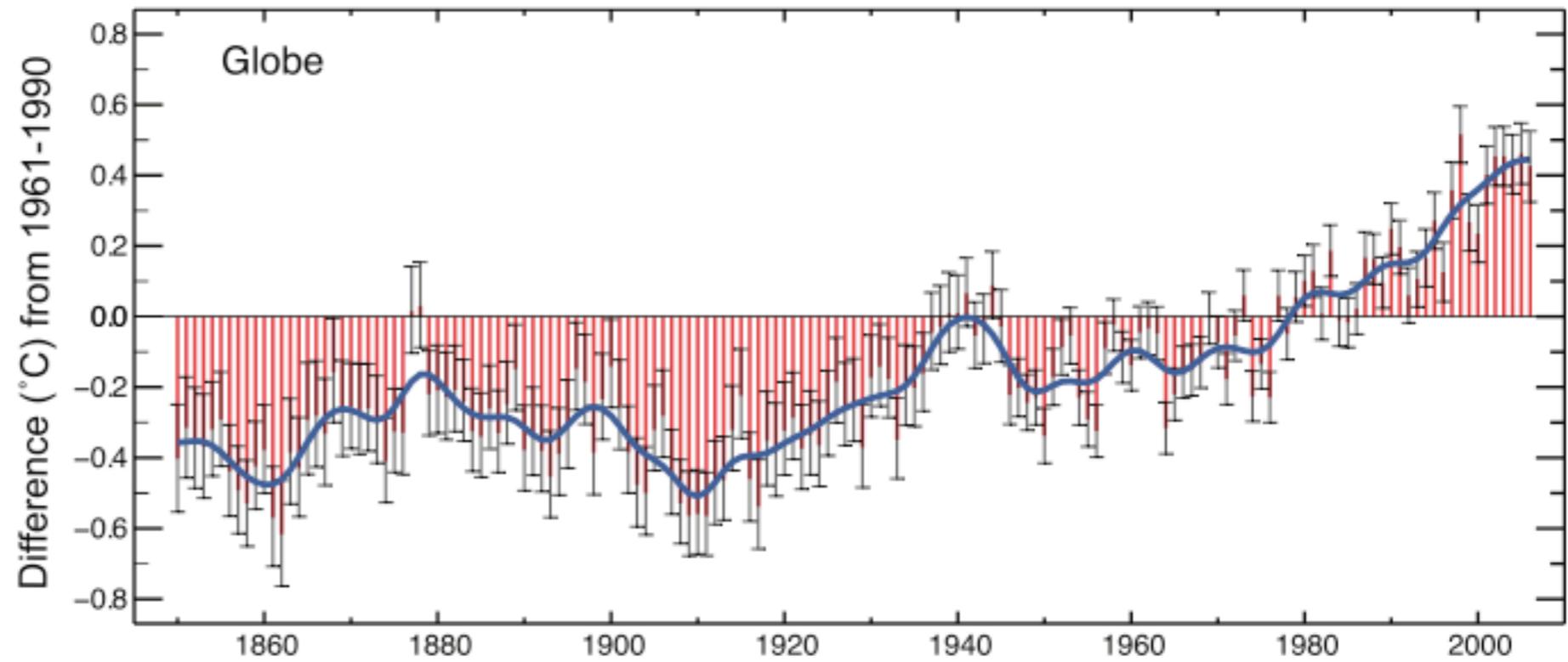


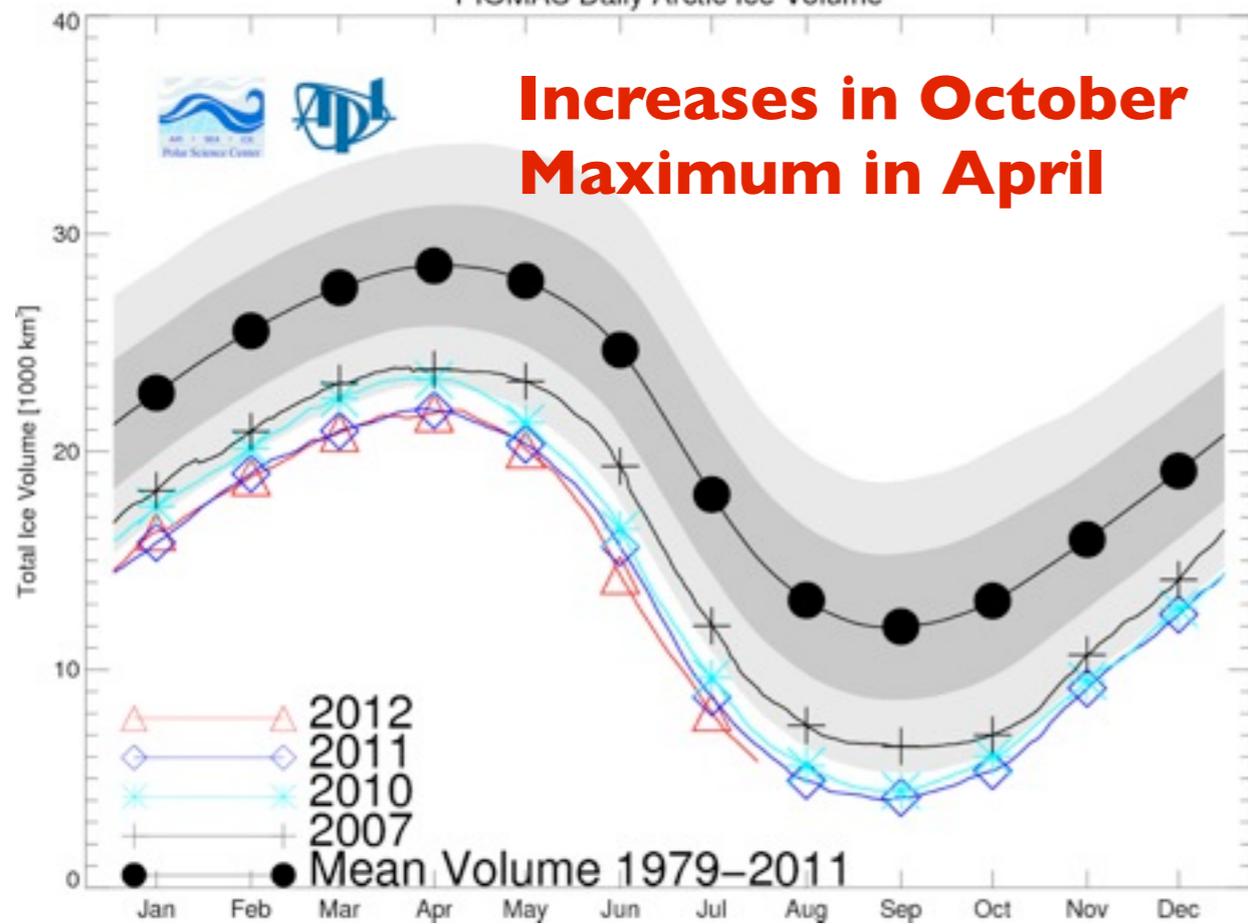
Roberts et al. (2010)

complex interactions among the atmosphere, land surface, and the sea ice covered Arctic Ocean

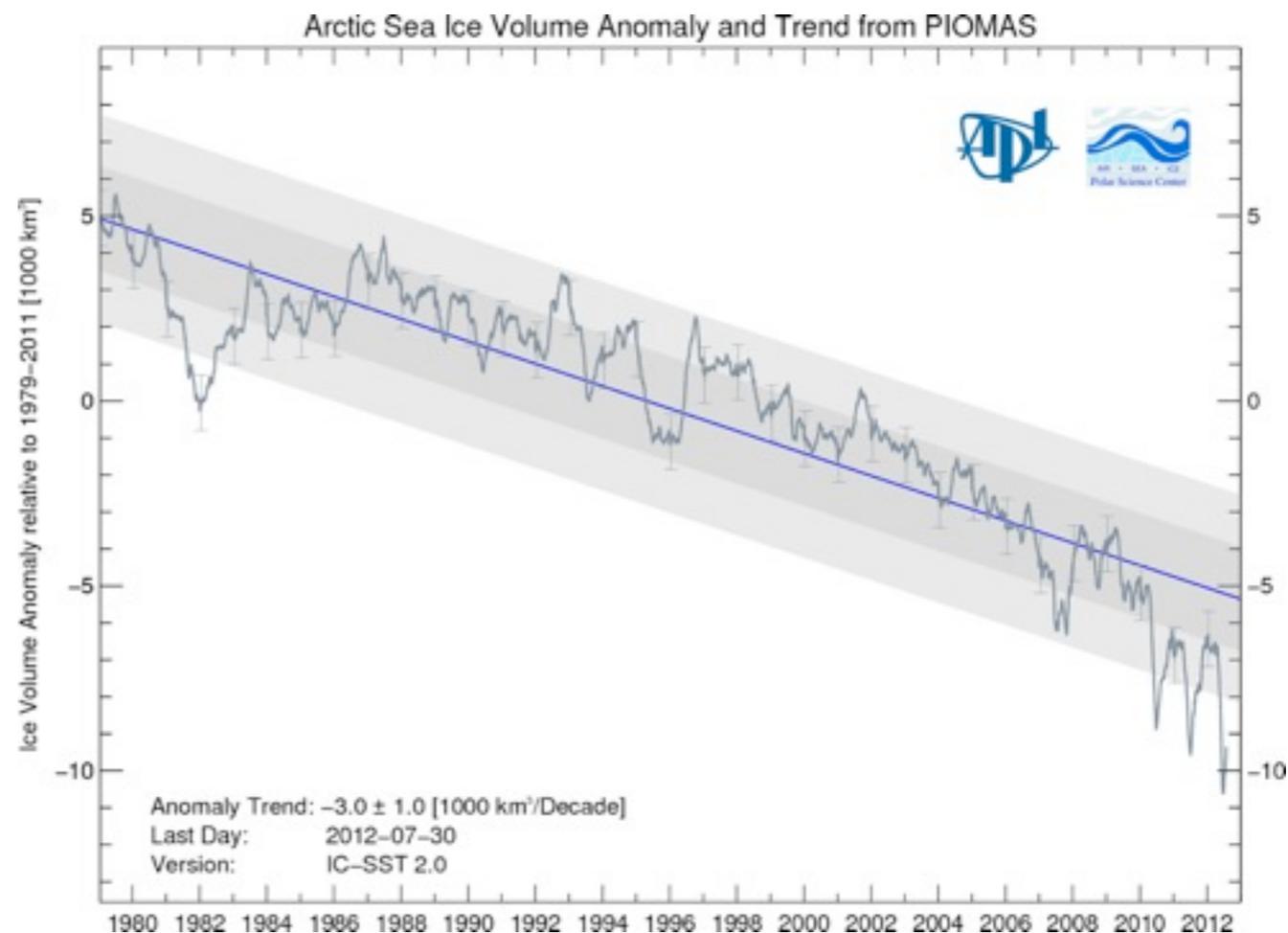
Surface Temperature Warming

Warming in Arctic has nearly doubled that of Earth





Sea Ice Volume
ice thickness * ice extent





Complex Arctic System
+
Warming Surface Temperatures
+
Melting of snow and ice
=
**important impacts on Arctic region
and
Earth's climate**

How does SpCAM represent the characteristics of the Arctic climate system?

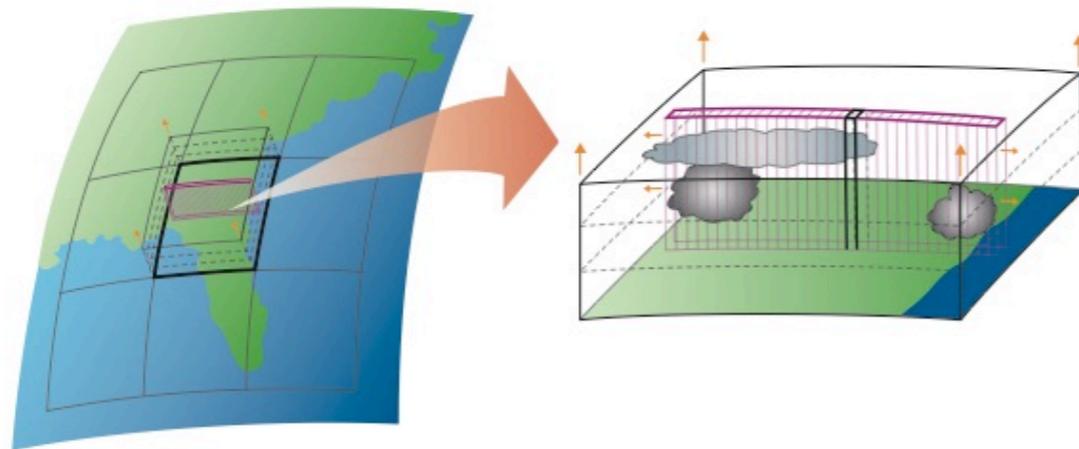
Present day 4xCO₂ Climate

Focus:

Mean Sea Level Pressure
Surface Temperature
Precipitable Water
Sea Ice Concentration
Total Cloud Fraction
Downwelling Longwave Radiation

Models

Simulation Info	CAM	SpCAM
CO ₂ - <i>Present Day</i>	368 ppm	368 ppm
CO ₂ - <i>Abrupt 4xCO₂</i>	1120 ppm	1120 ppm
Cloud parameterizations	Yes	No, 2-D CRM
Ocean Model	SOM	SOM



Schematic of 2D CRM
(Randall 2003)

Observations

ERA Interim

Monthly mean data
1989-present

SSM/I/SMMR

Sea Ice Concentration
1979-1999

NVAP-MEASURES

Water Vapor
2006-2008

Mean SLP - Present Day

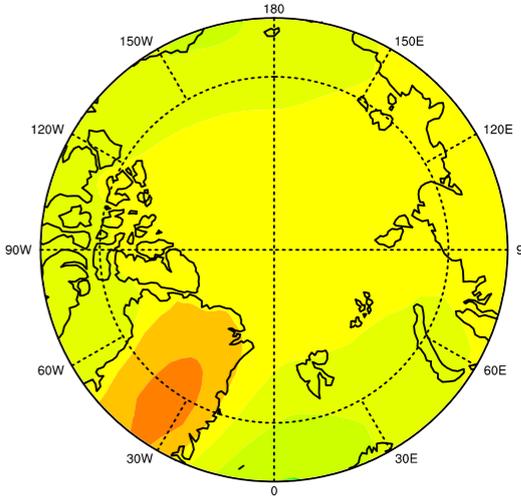
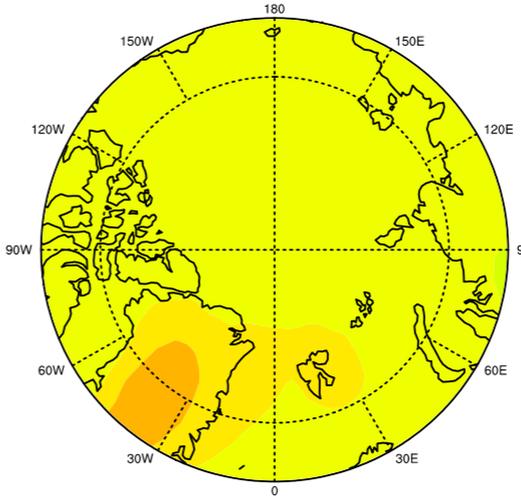
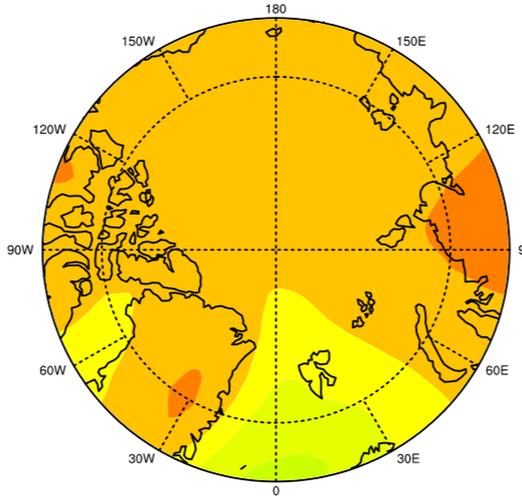
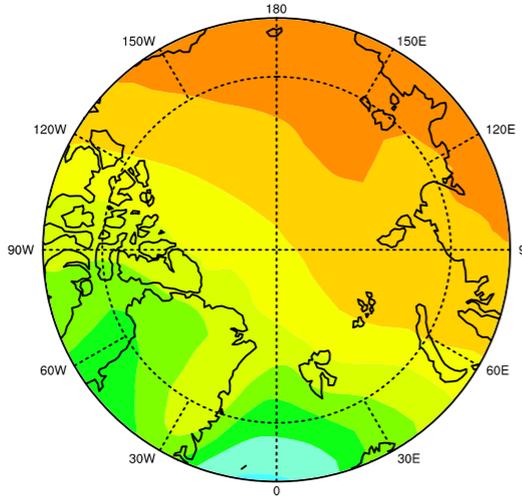
DJF

MAM

JJA

SON

CAM



SPCAM DJF

mb

SPCAM MAM

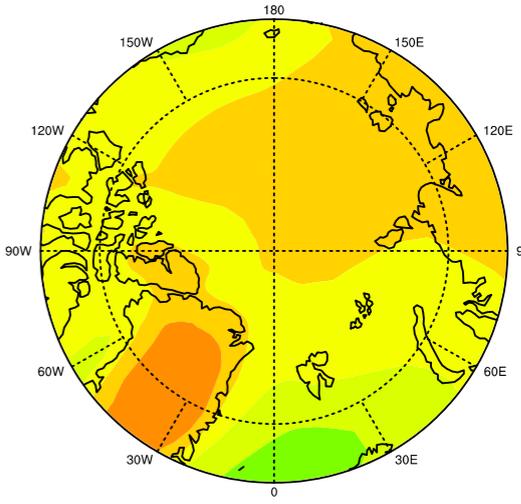
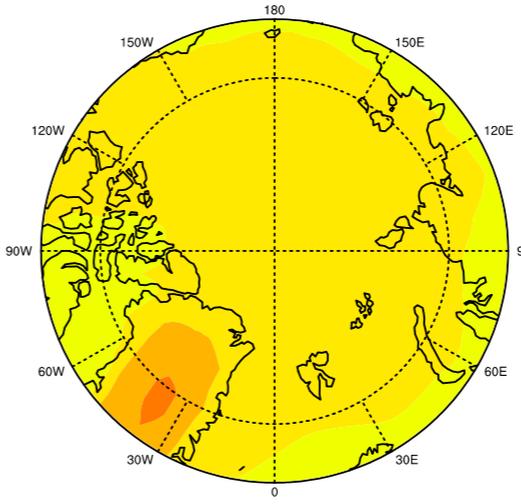
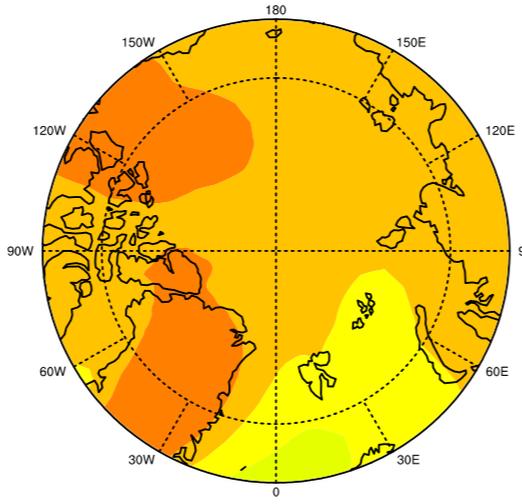
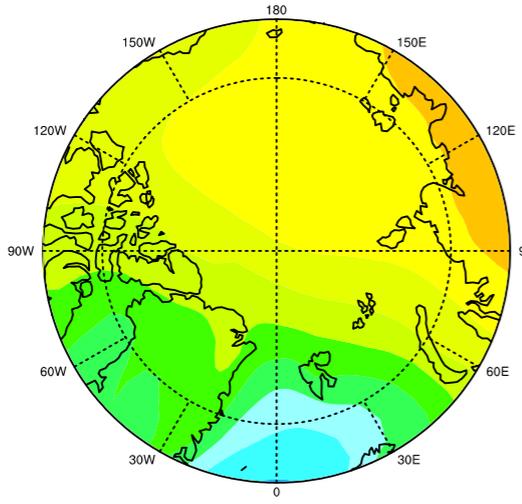
mb

SPCAM JJA

mb

SPCAM SON

mb



SpCAM

ERA-Interim DJF

mb

ERA-Interim MAM

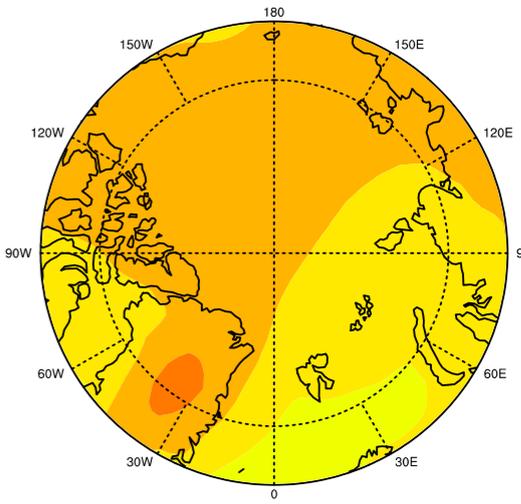
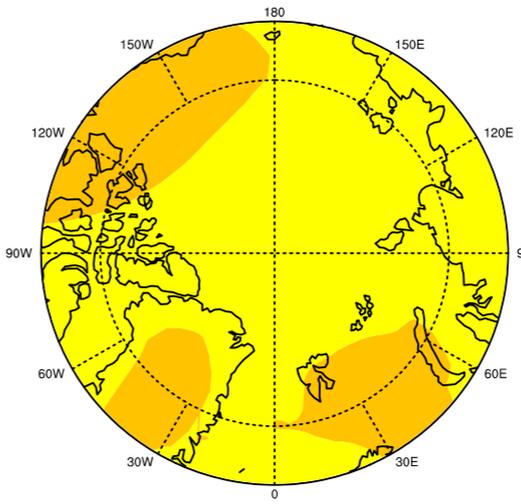
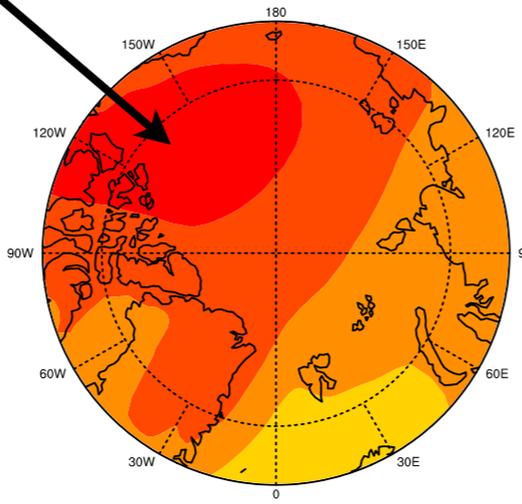
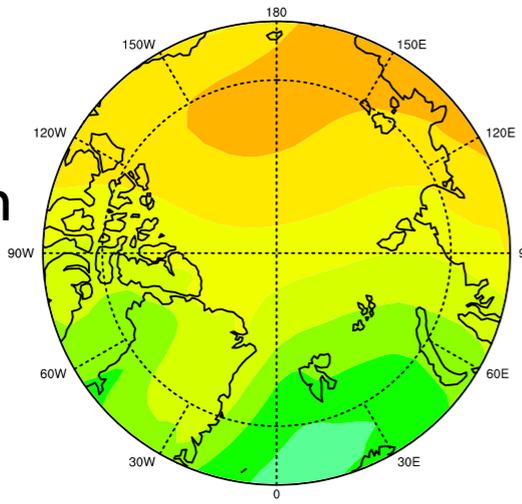
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ERA-Interim JJA

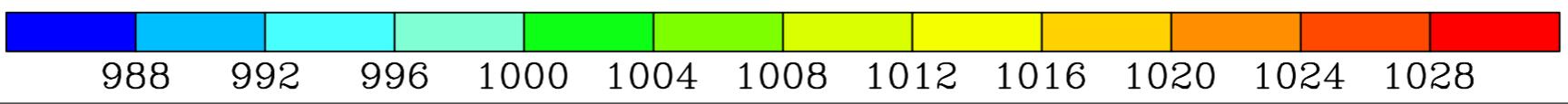
mb

ERA-Interim SON

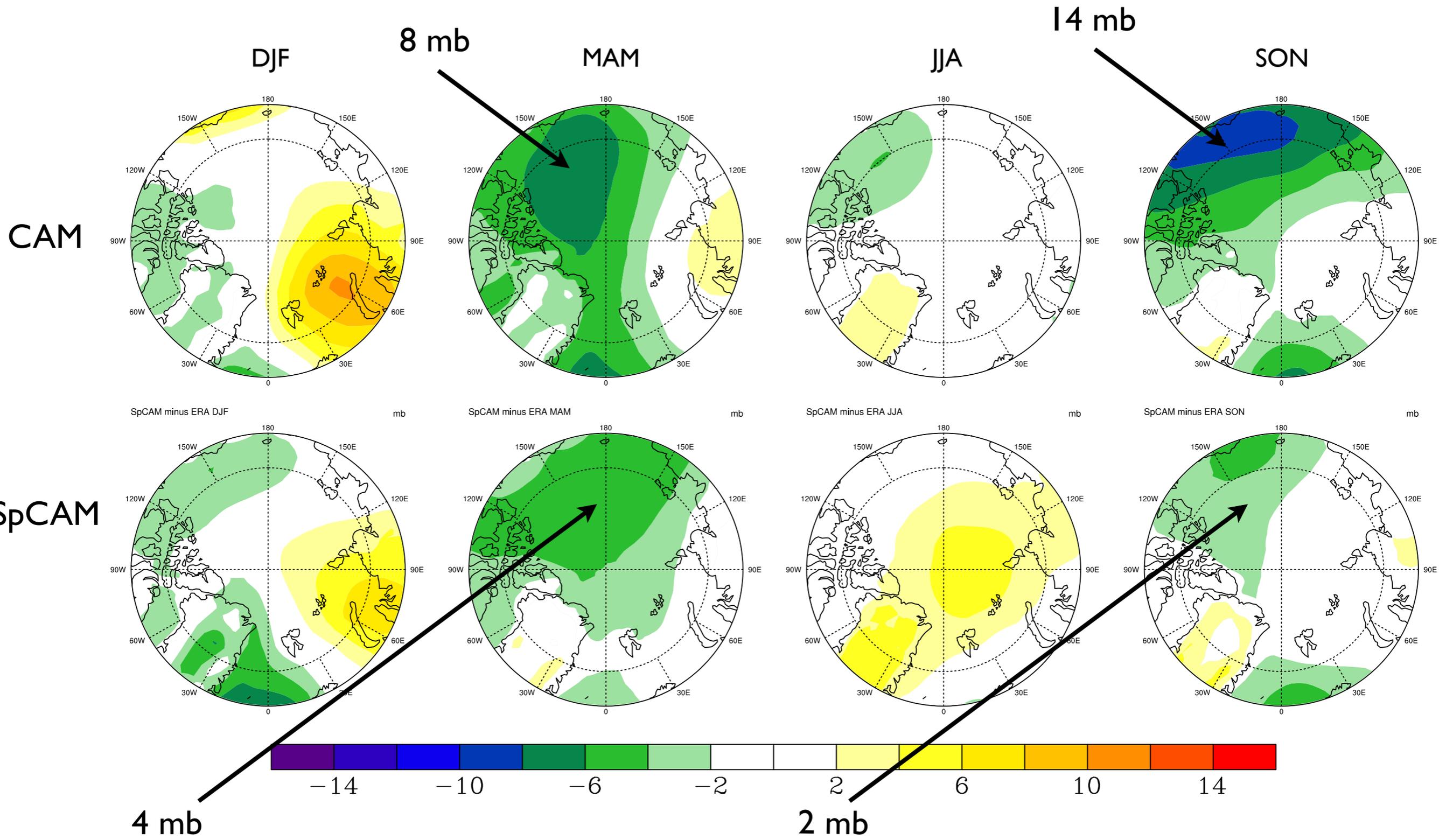
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ERA-Interim



Mean SLP Bias



CAM

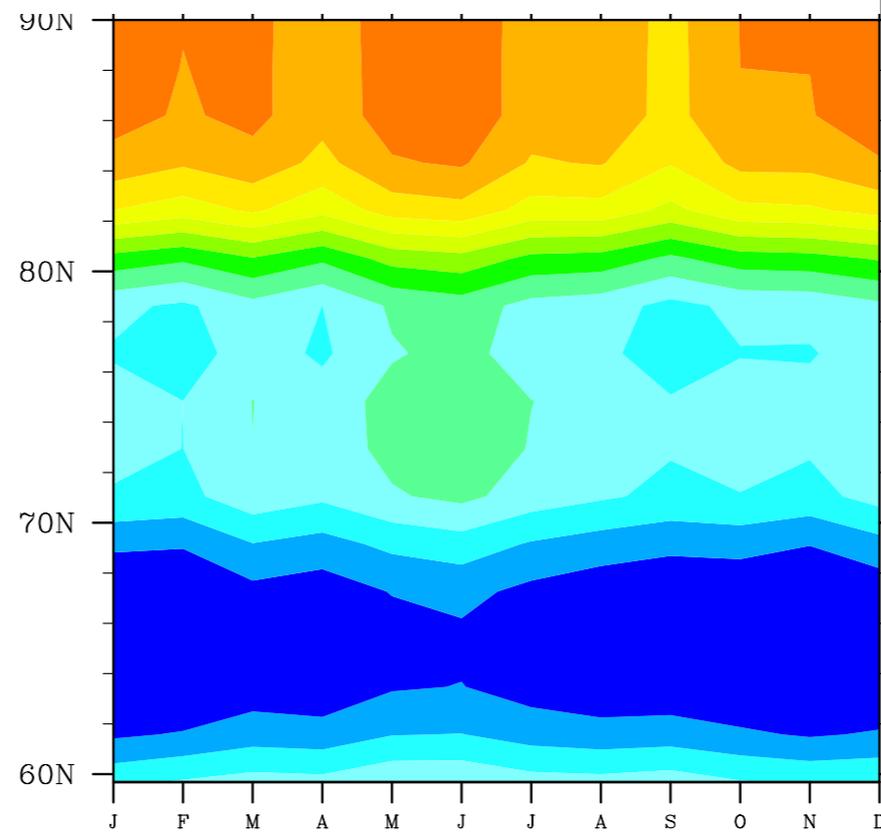
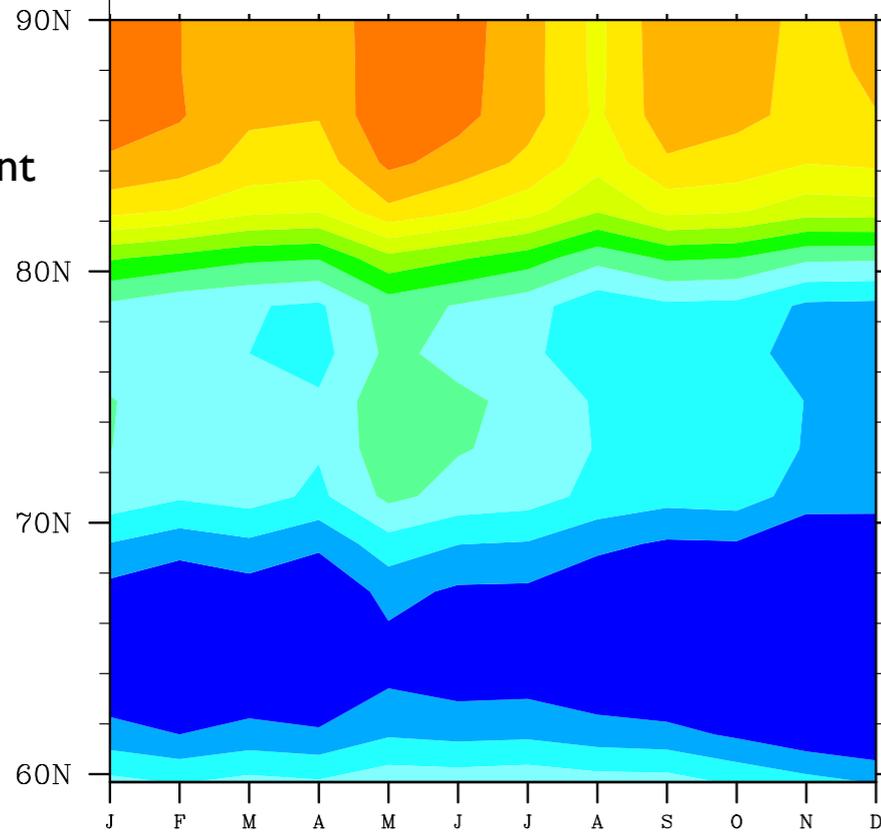
SpCAM

Mean SLP

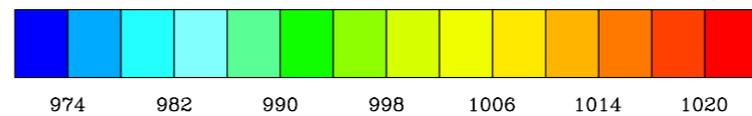
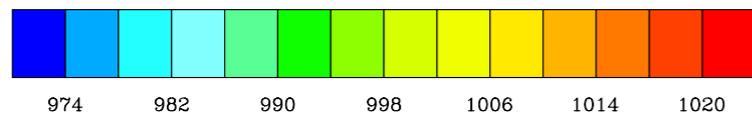
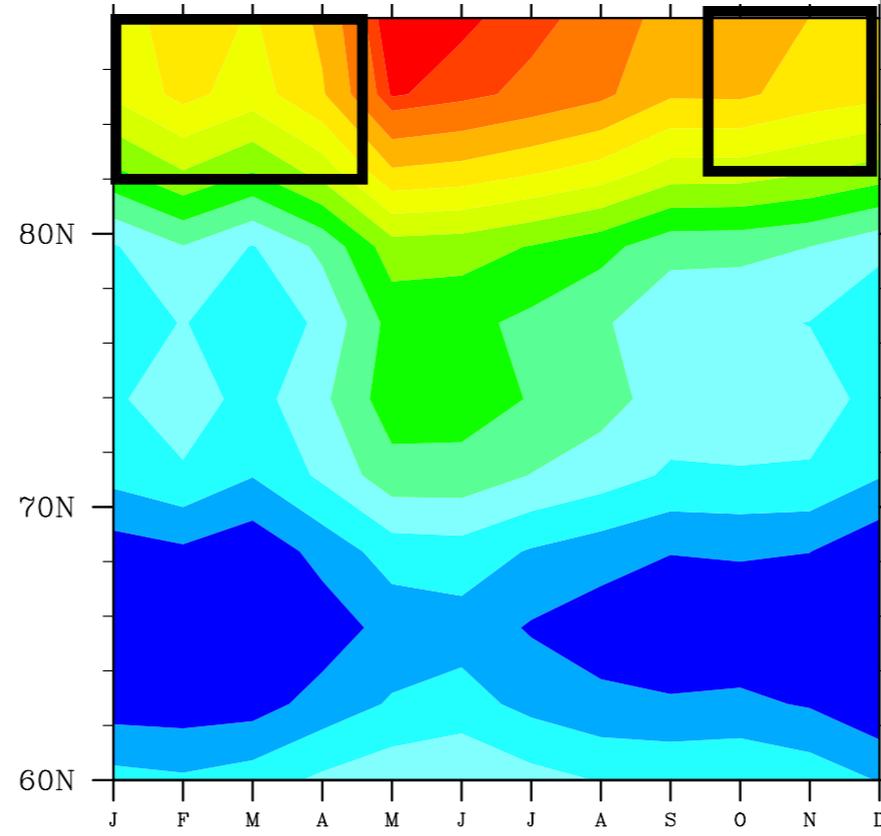
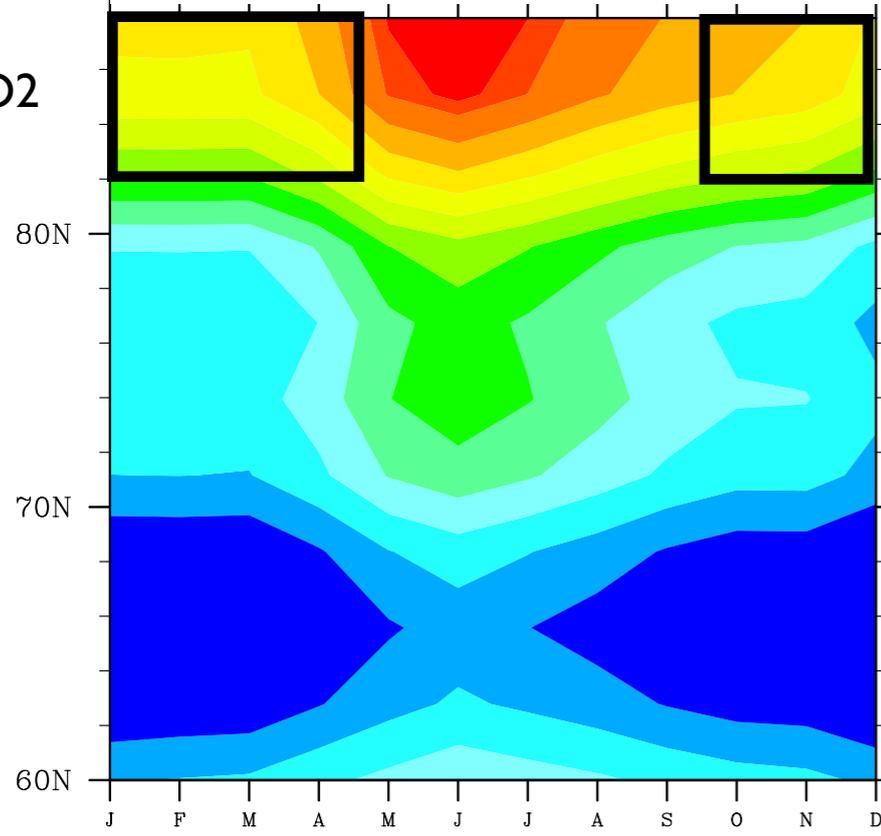
decreased pressure in winter months ~10mb

slight increases in summer

Present



4xCO2



Surface Air Temperature - Present Day

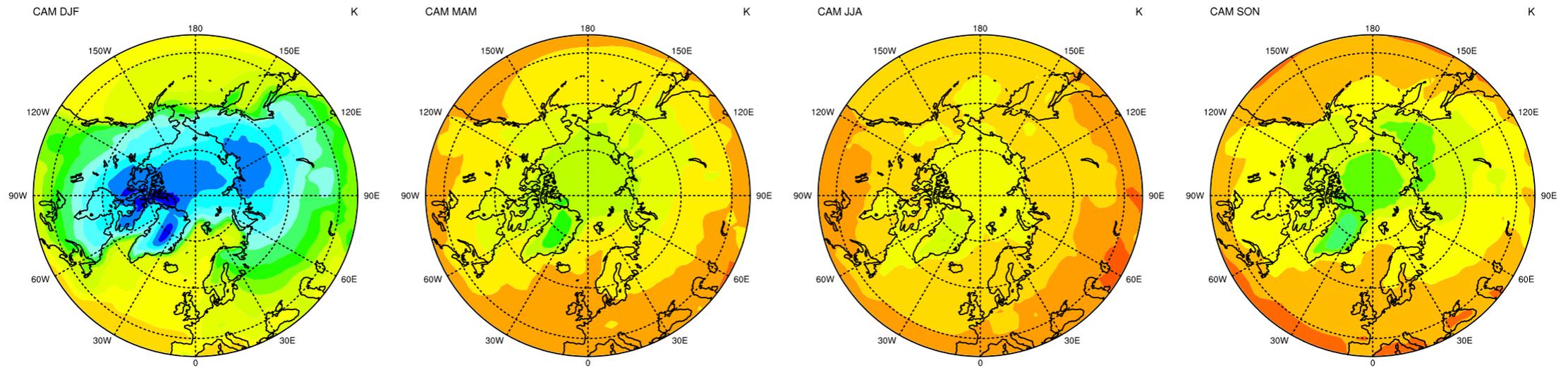
DJF

MAM

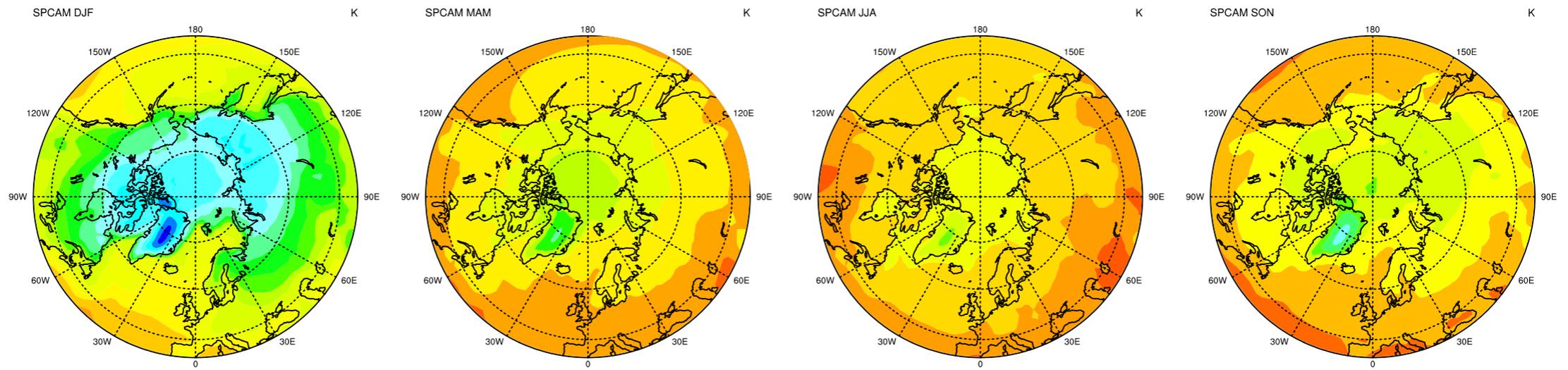
JJA

SON

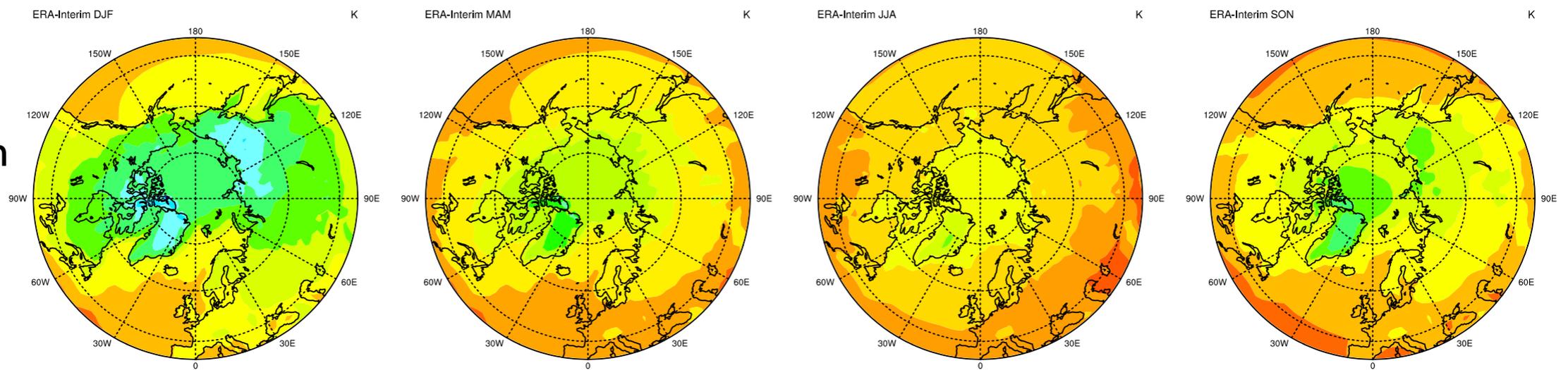
CAM



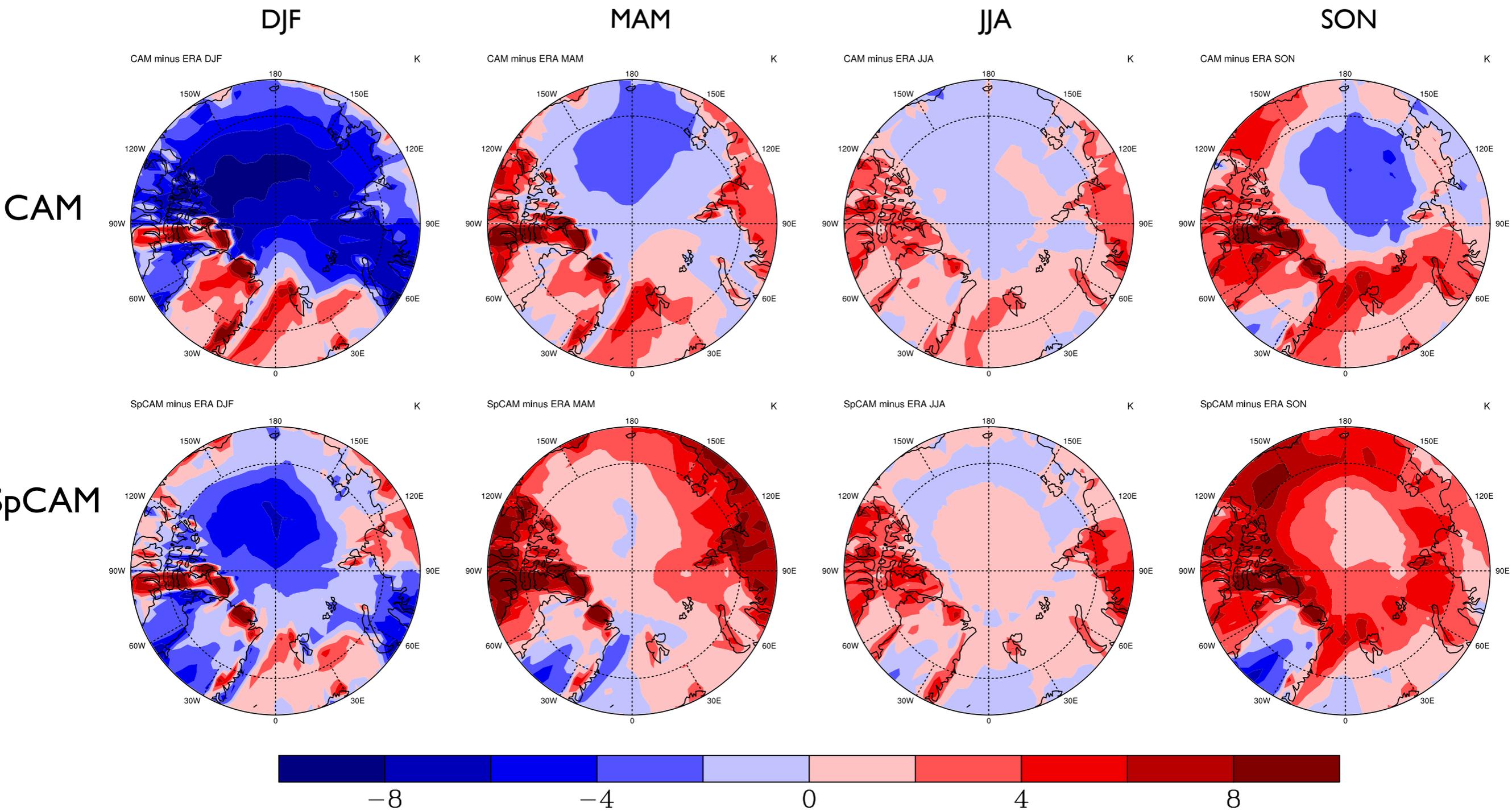
SpCAM



ERA-Interim



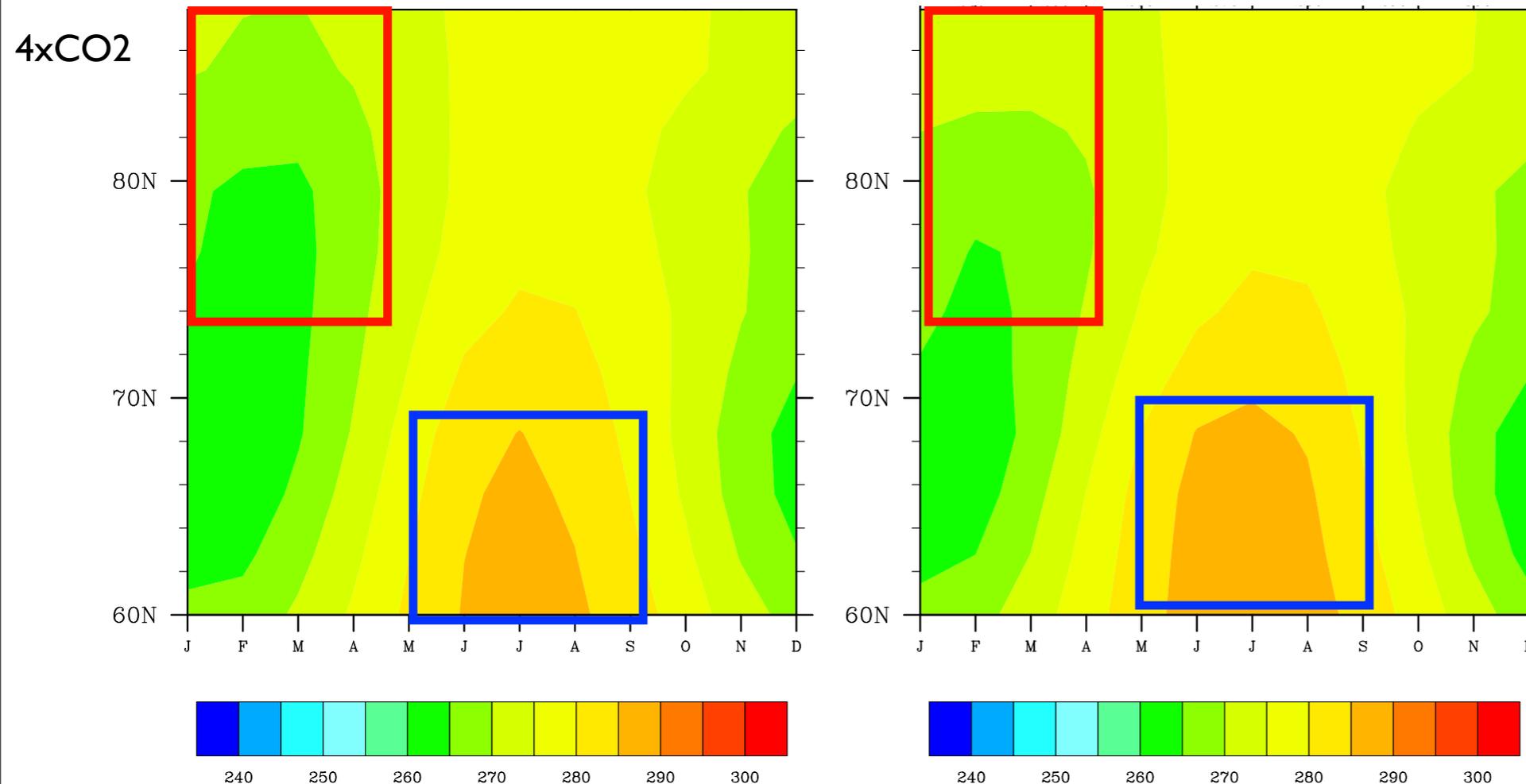
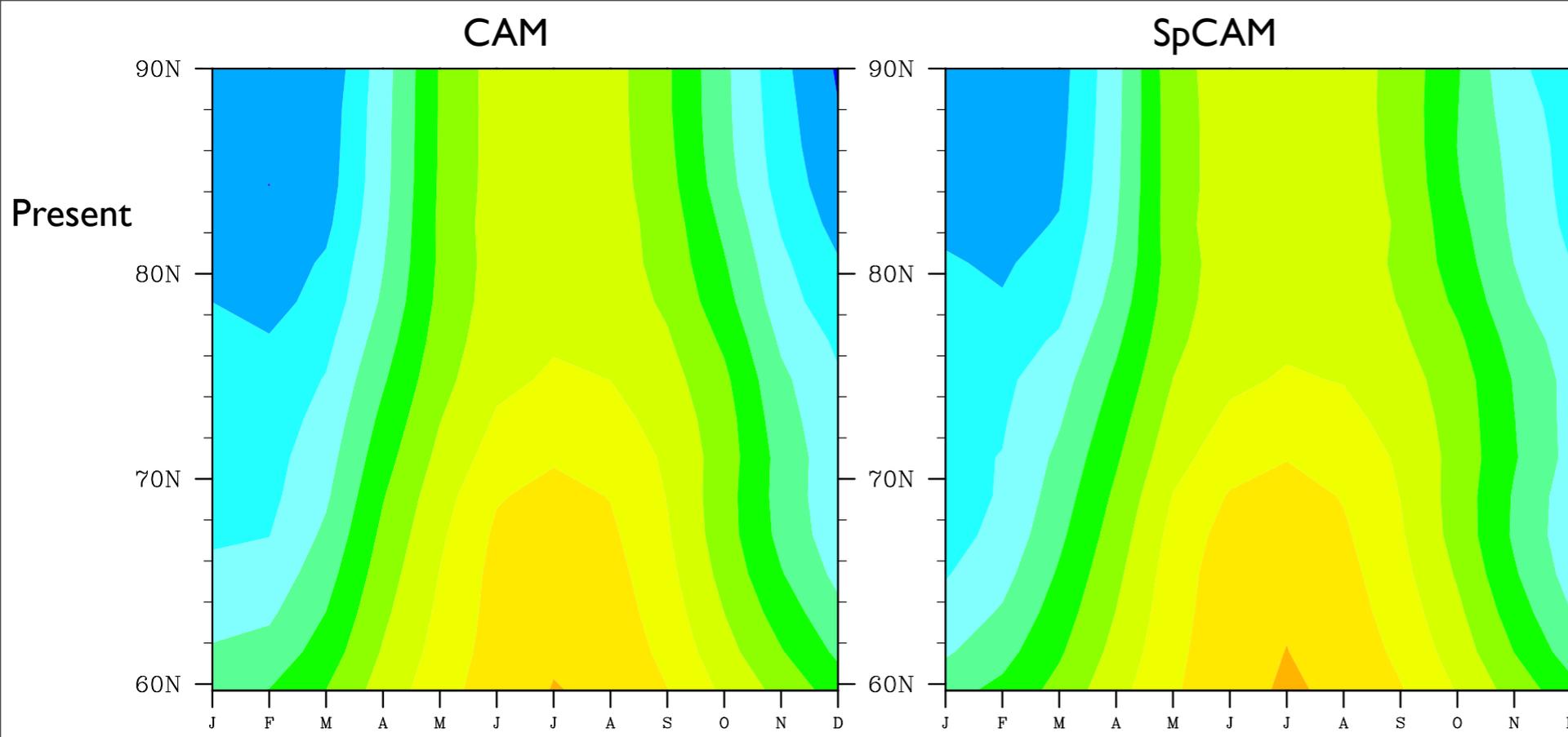
Surface Air Temperature Bias



Biases are largest in winter months compared to summer

Possibly due to temps over ice oscillating around freezing during summer

Surface Air Temp



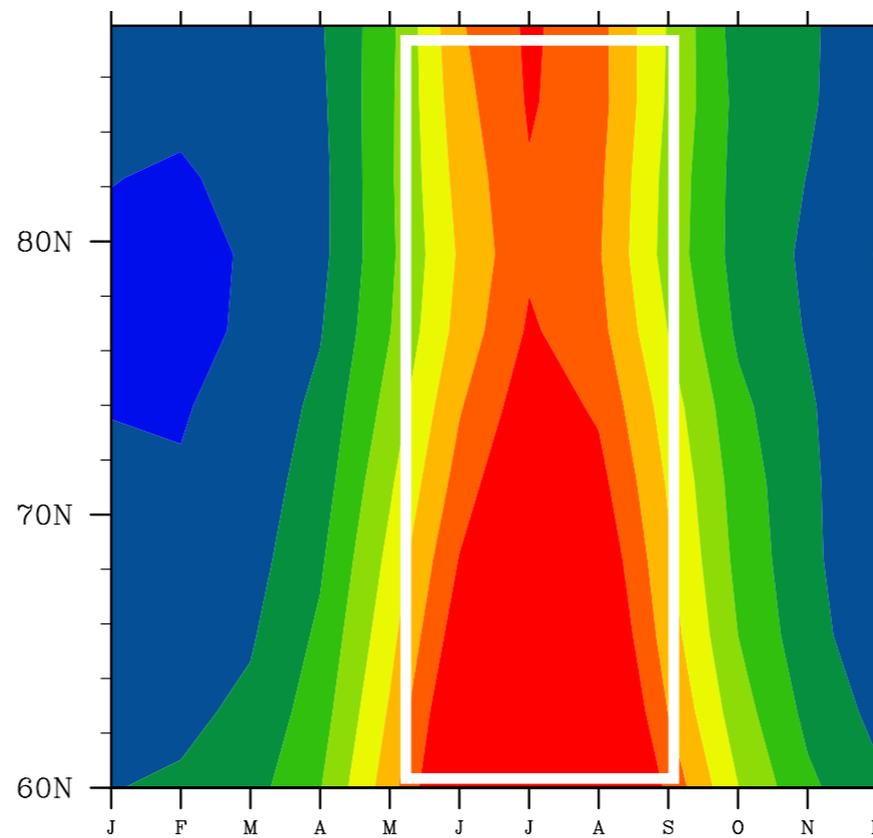
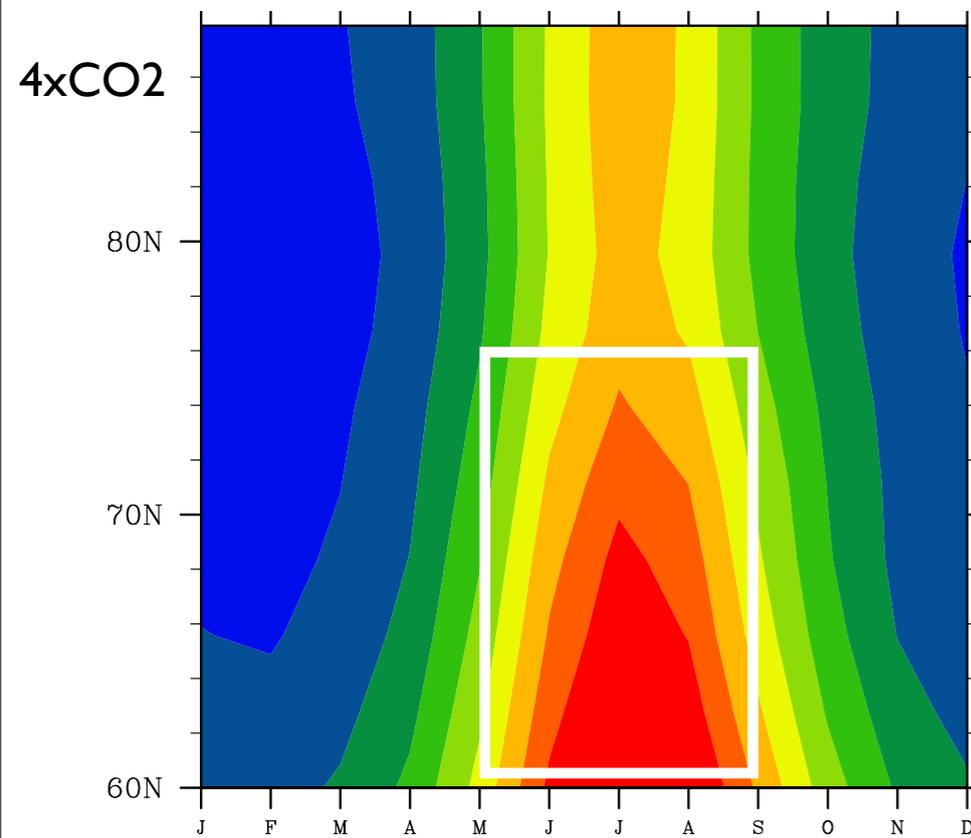
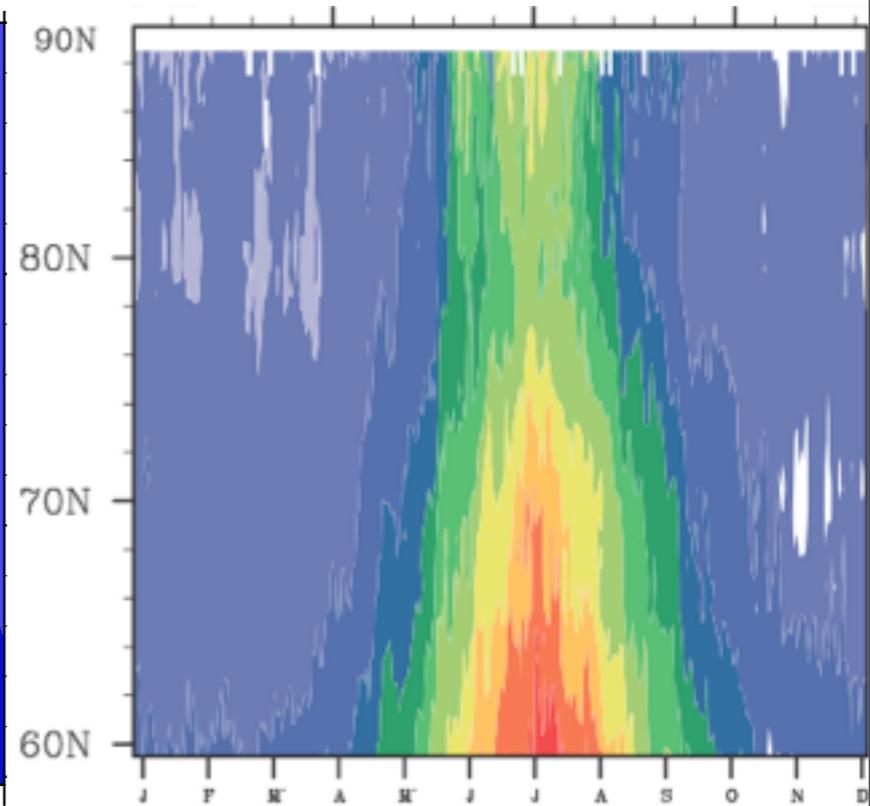
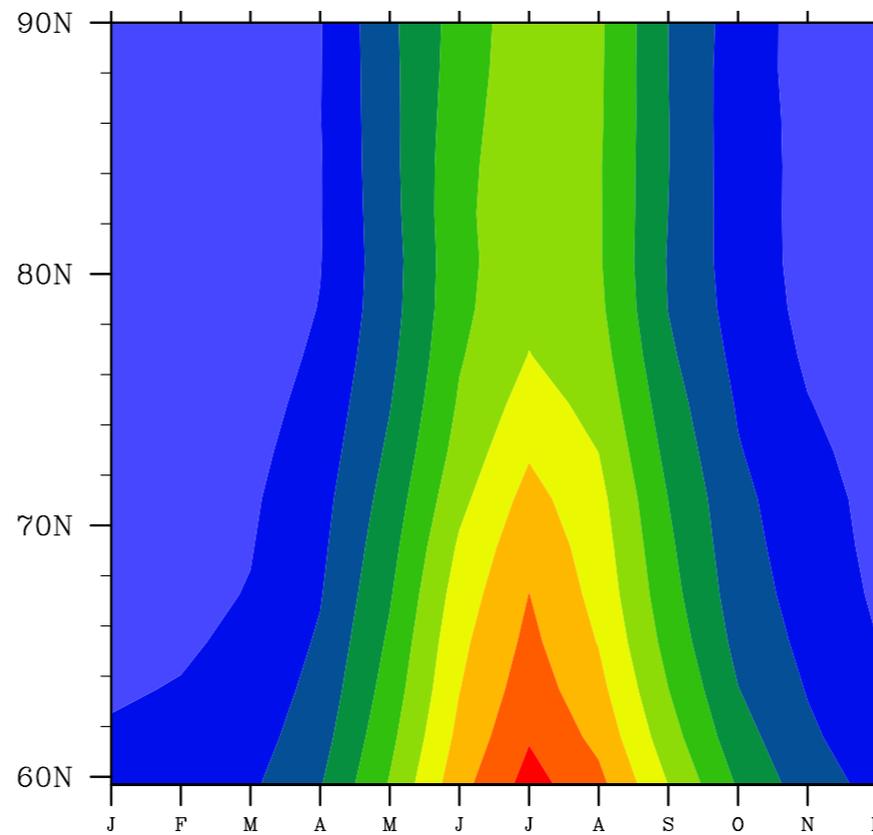
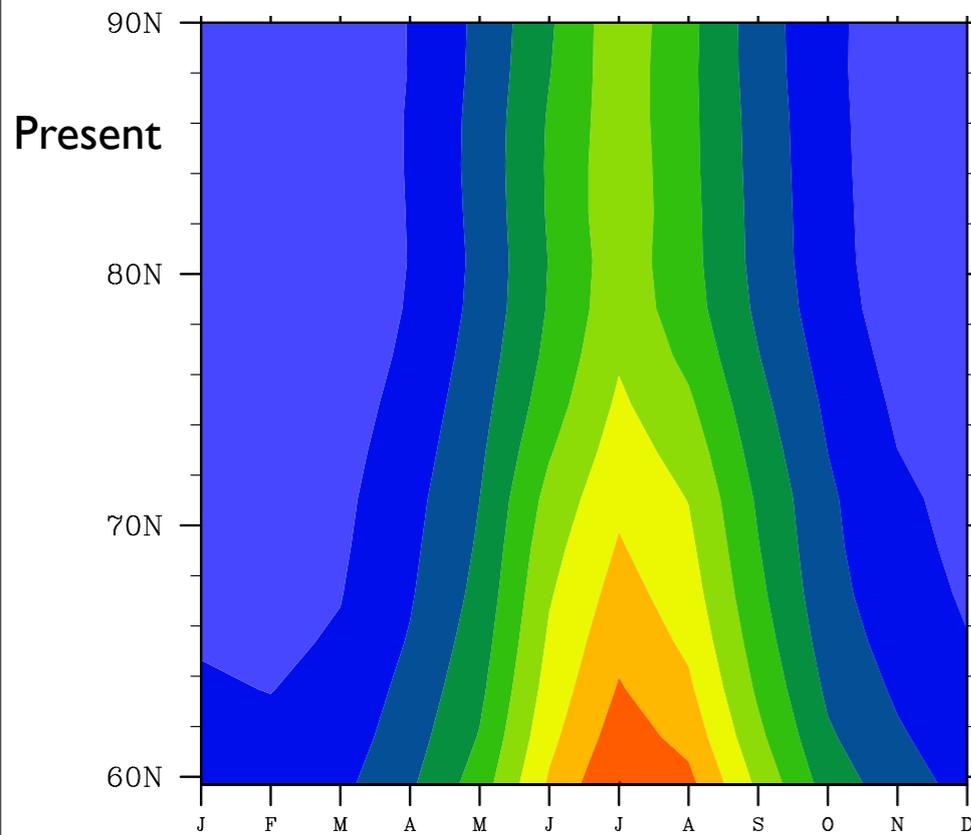
Greatest warming in winter ~8K

Summer ~5K

CAM

SpCAM

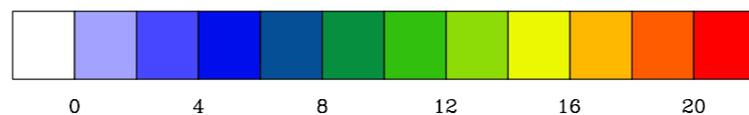
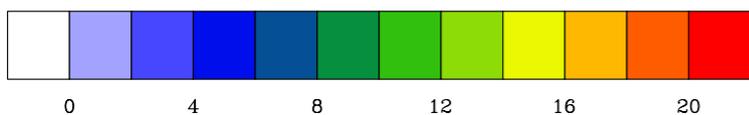
NVAP



Precipitable Water

More PW throughout Arctic

SpCAM has earlier onset
more moisture

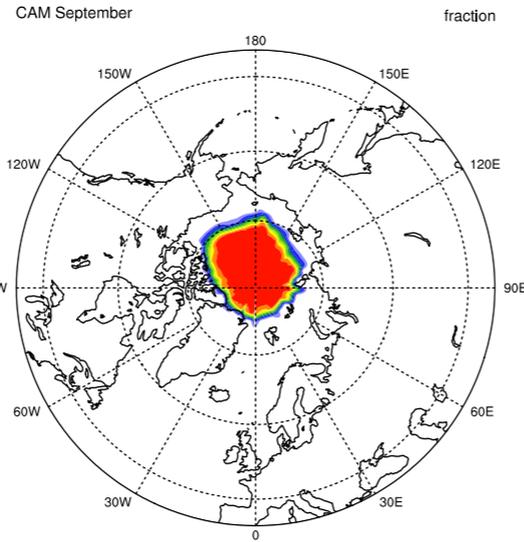
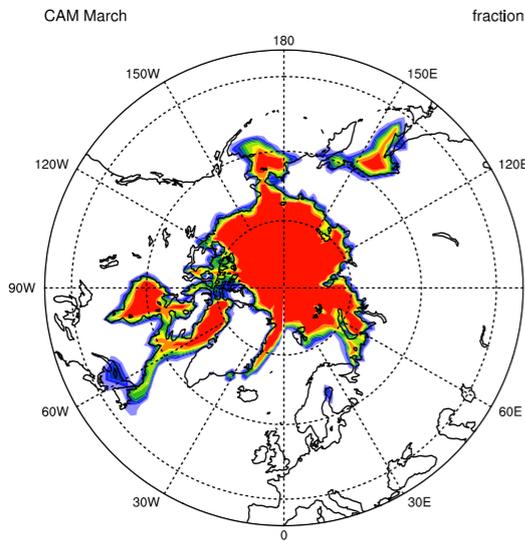


**Present
Day**

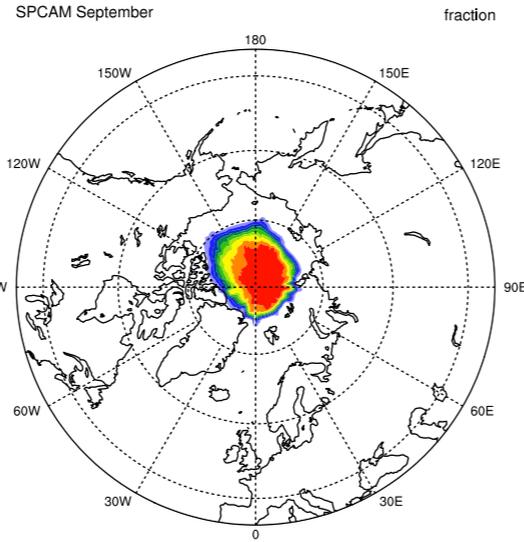
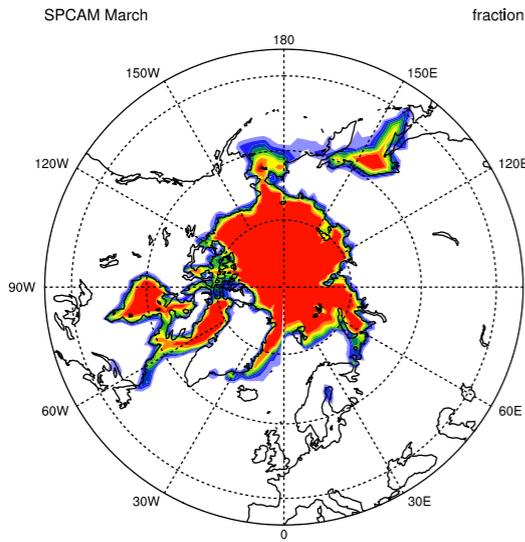
March

Sept

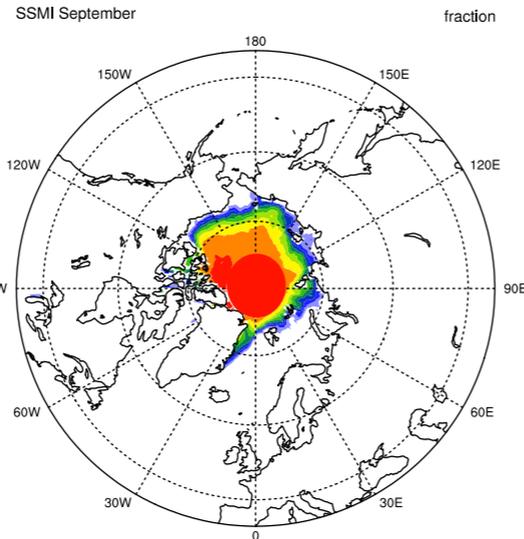
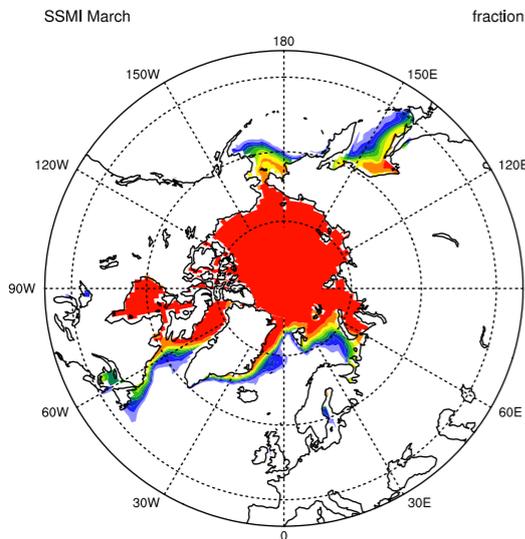
CAM



SpCAM



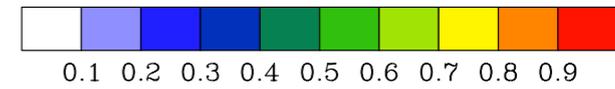
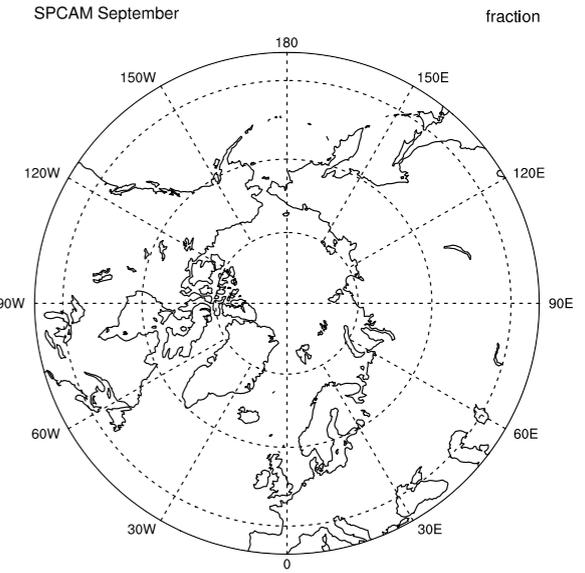
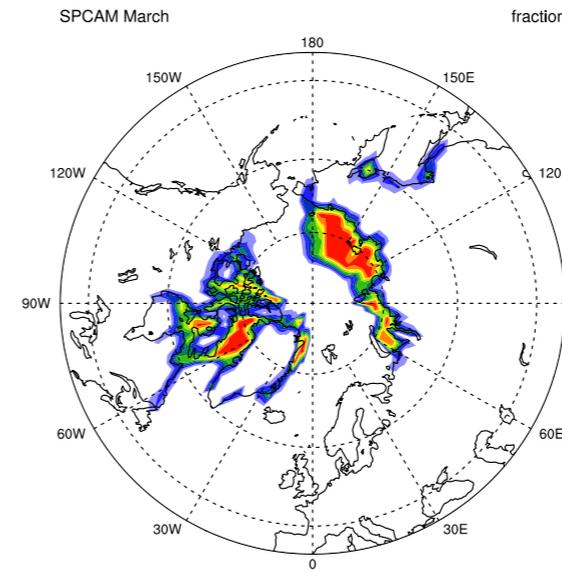
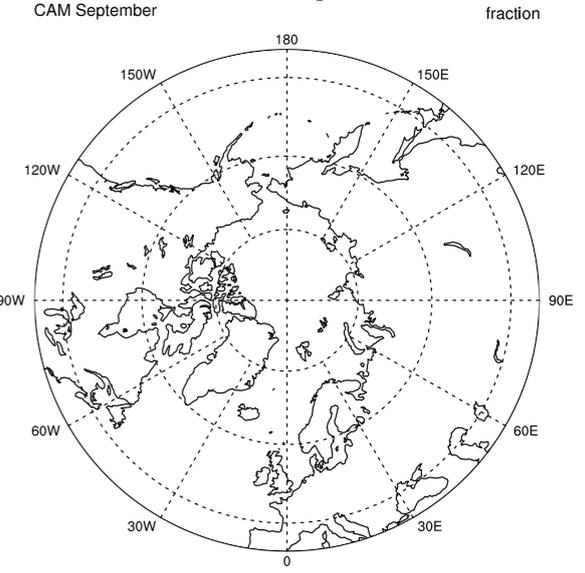
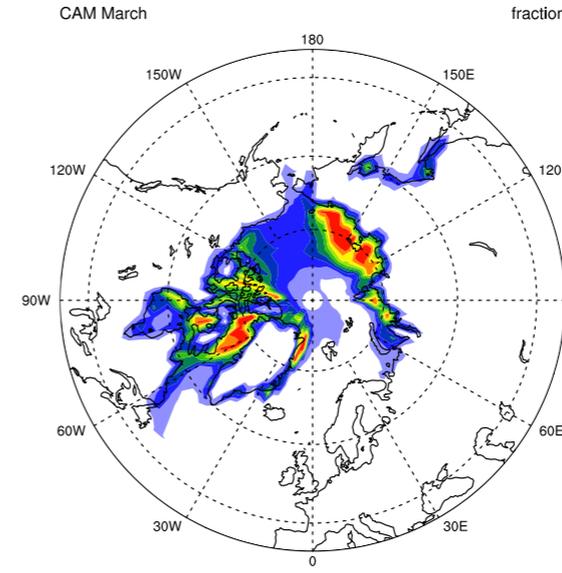
SSMI



4xCO₂

March

Sept

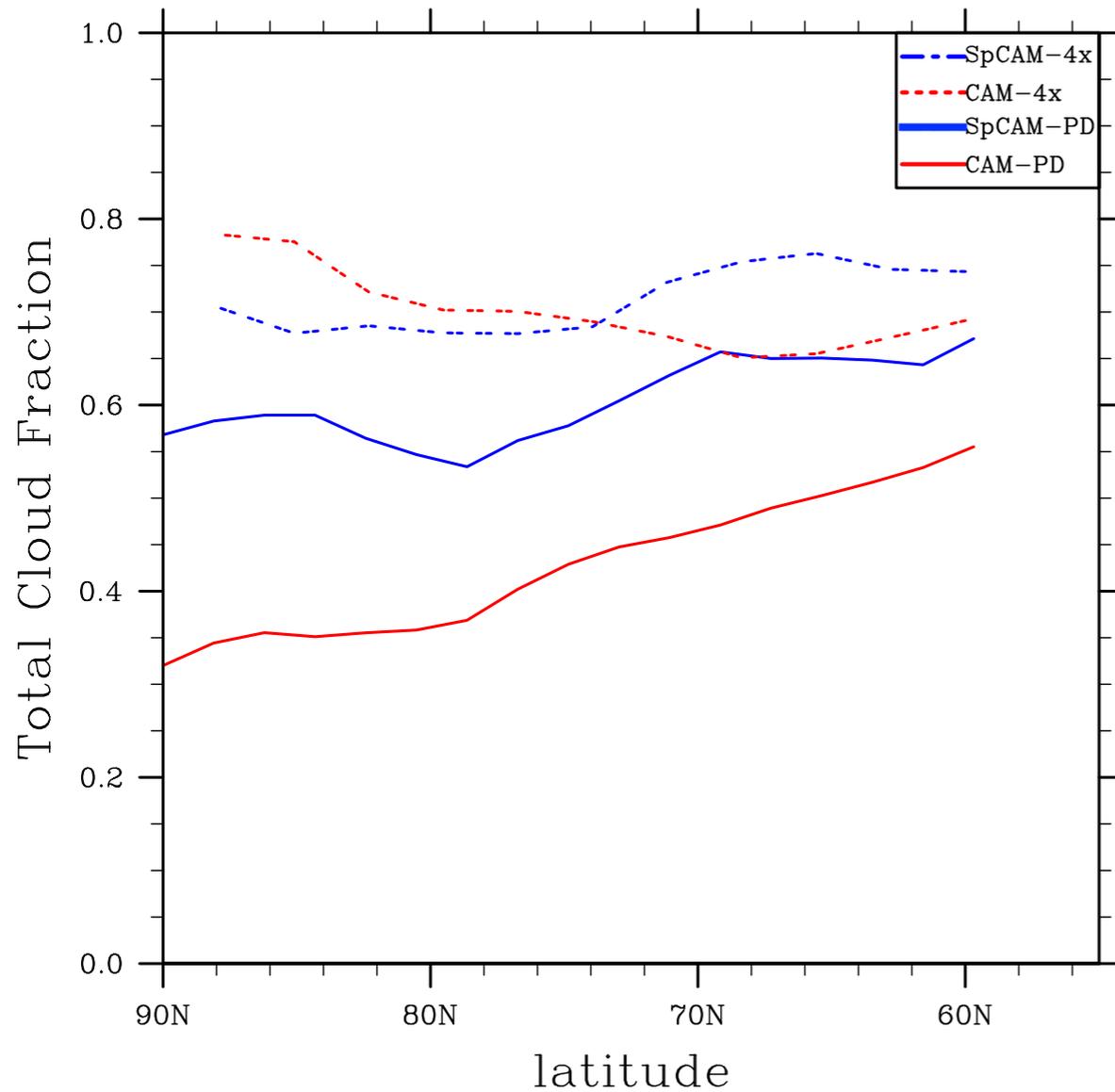


Sea Ice Fraction

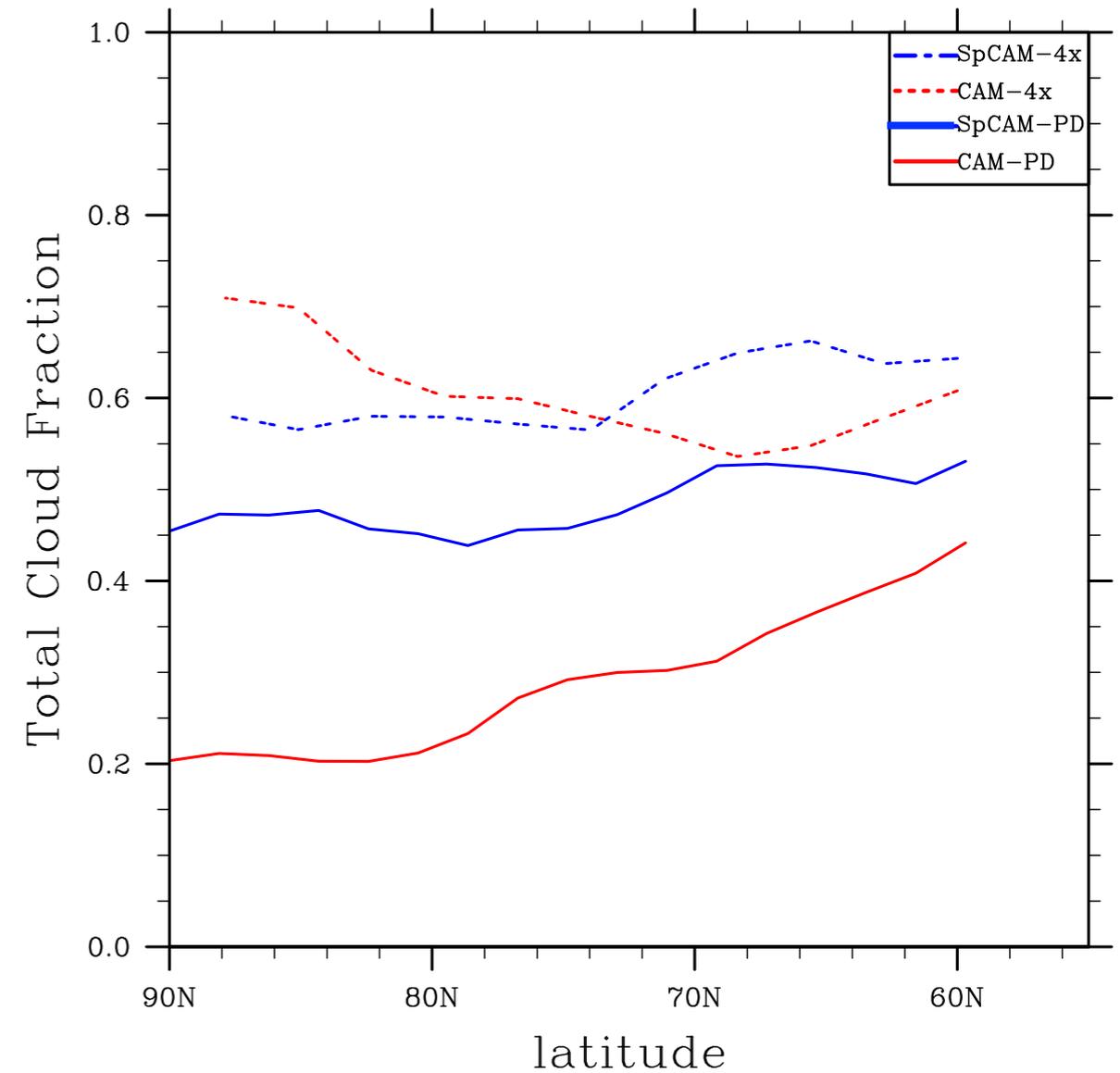
Significant decline in Sea Ice

sea ice tends to hug the continents

Total Cloud



Low Cloud



Increases in both total and low cloud
seasonally more low clouds in spring and fall

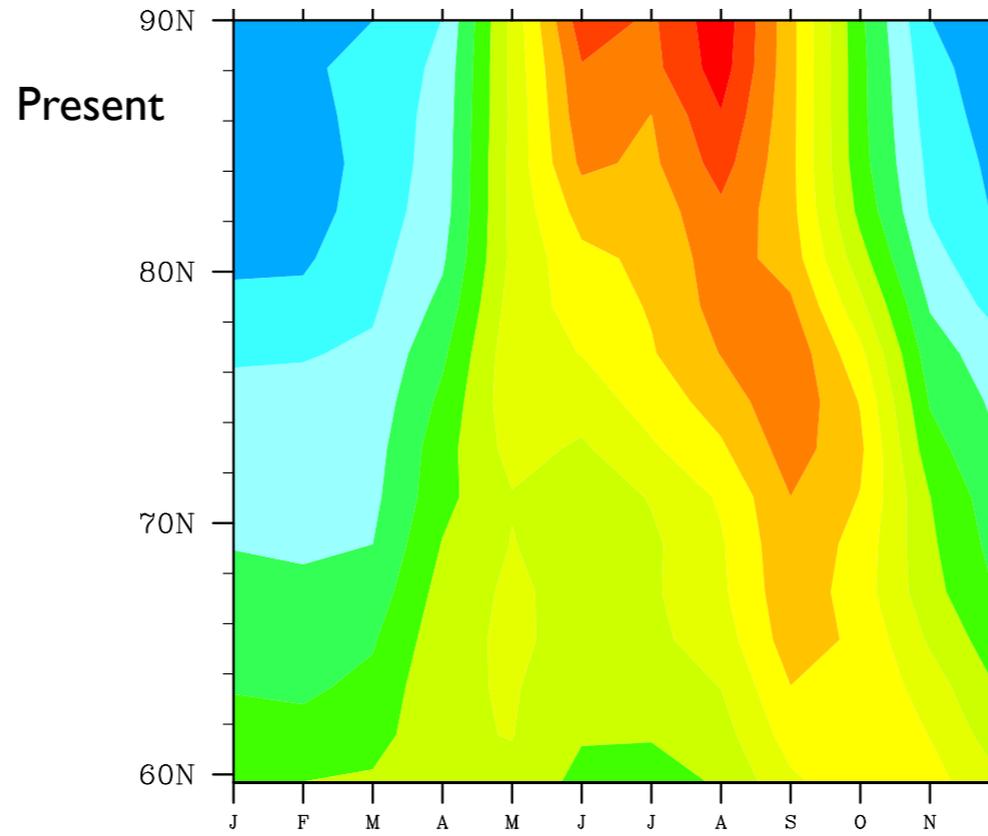
Downwelling Longwave Radiation

need to compare with obs

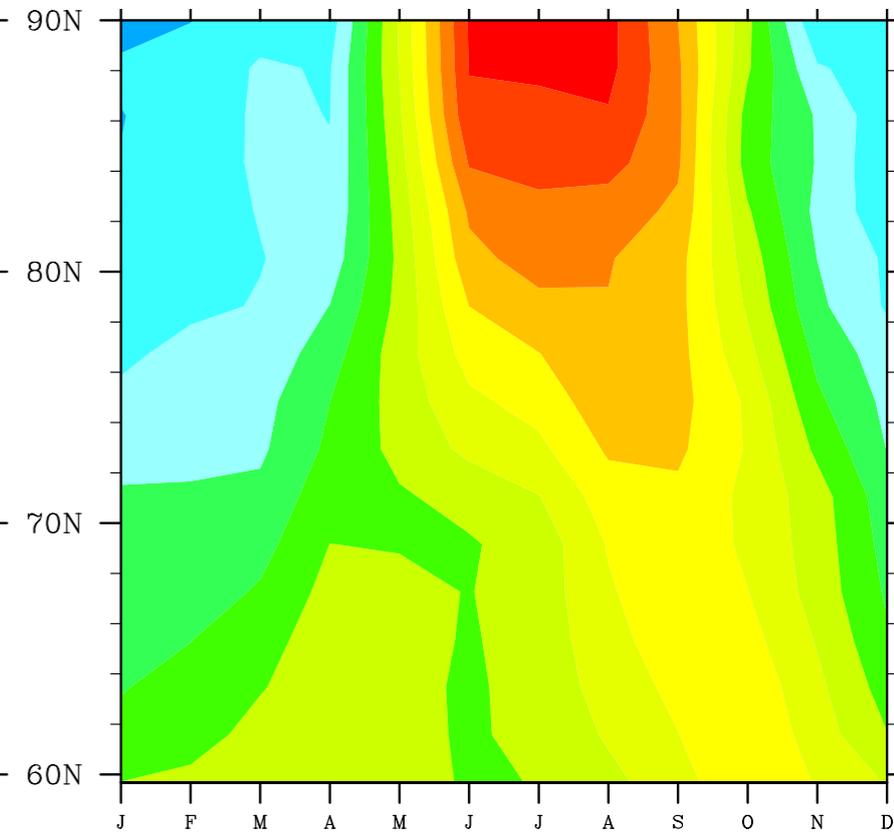
Increased downwelling LW in winter

have an impact on ice -- reduces the rate of ice thickening

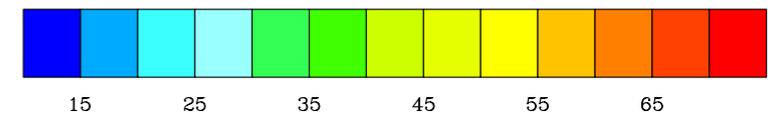
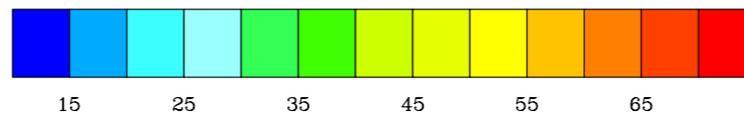
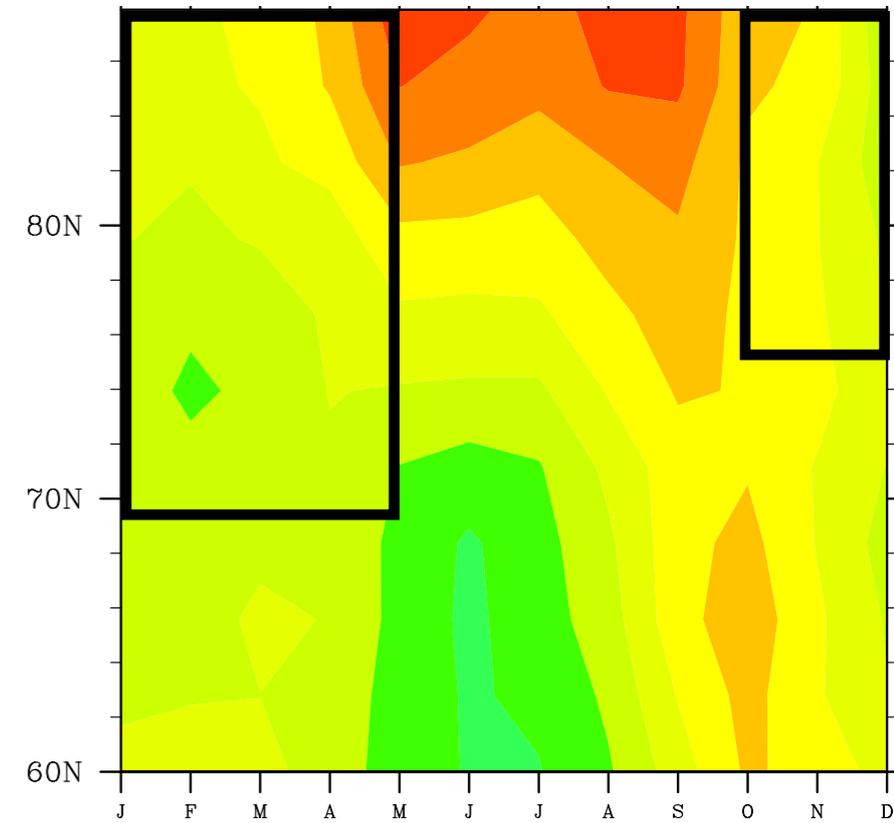
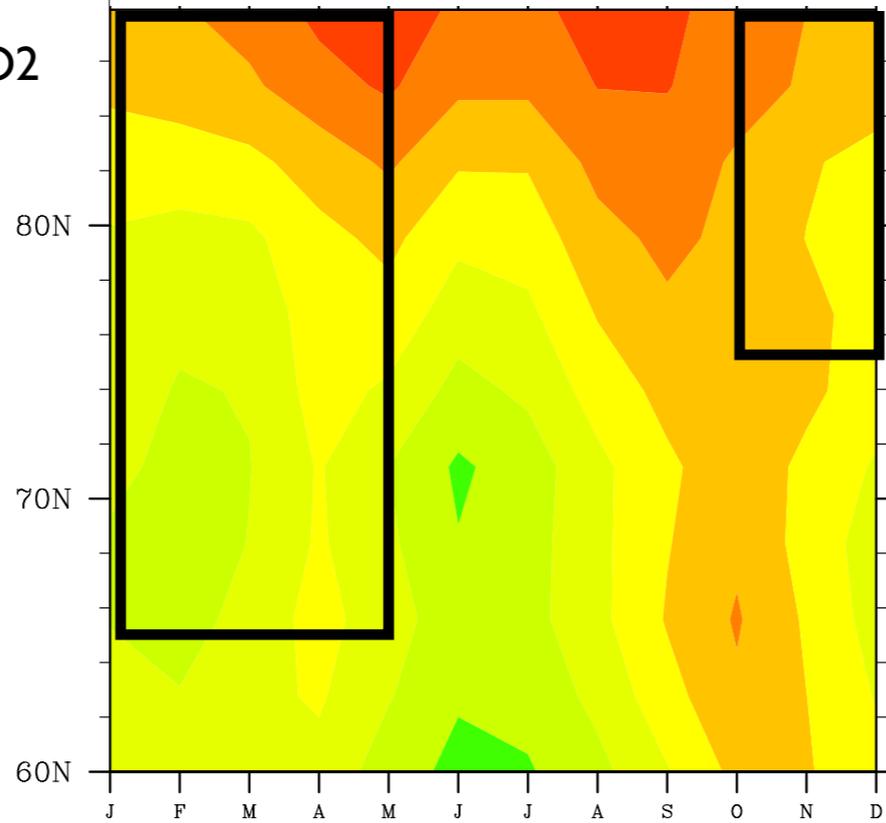
CAM



SpCAM



4xCO2



Recap

Analyzed characteristics of the Arctic in CAM and SpCAM -- Present Day and 4xCO₂

Present Day

Both models generally agree with observations in surface temperature, water vapor, sea ice
Underestimate mean SLP in winter and fall months, with CAM having largest biases
Large differences in total and low cloud

4xCO₂

Decreased mean SLP in winter months ~10mb -- expect some changes in seasonal high/low systems
Surface temperatures warm in winter ~8K, and summer ~5K -- greatest over land
More moisture throughout the Arctic
Rapid decline of sea ice
Increases in cloudiness
More downwelling LW radiation

Feedback arises



stronger DLR will reduce the rate of ice thickening which leads to earlier melt back in the following summer

positive feedback

Next steps

- 1. compare present day simulations with more observations**
- 2. analyze these features in a coupled framework (CESM and SpCESM) and CMIP5**
- 3. look at the extent to which wintertime DLR has influenced the downward trend in arctic sea ice -- potential feedback**
- 4. understand the role of wintertime DLR in 21st century climate change**
- 5. look at the changes in sea ice (e.g. melt ponds, etc.) and effect on radiation**
- 6. and much more to be decided SOON**

Questions